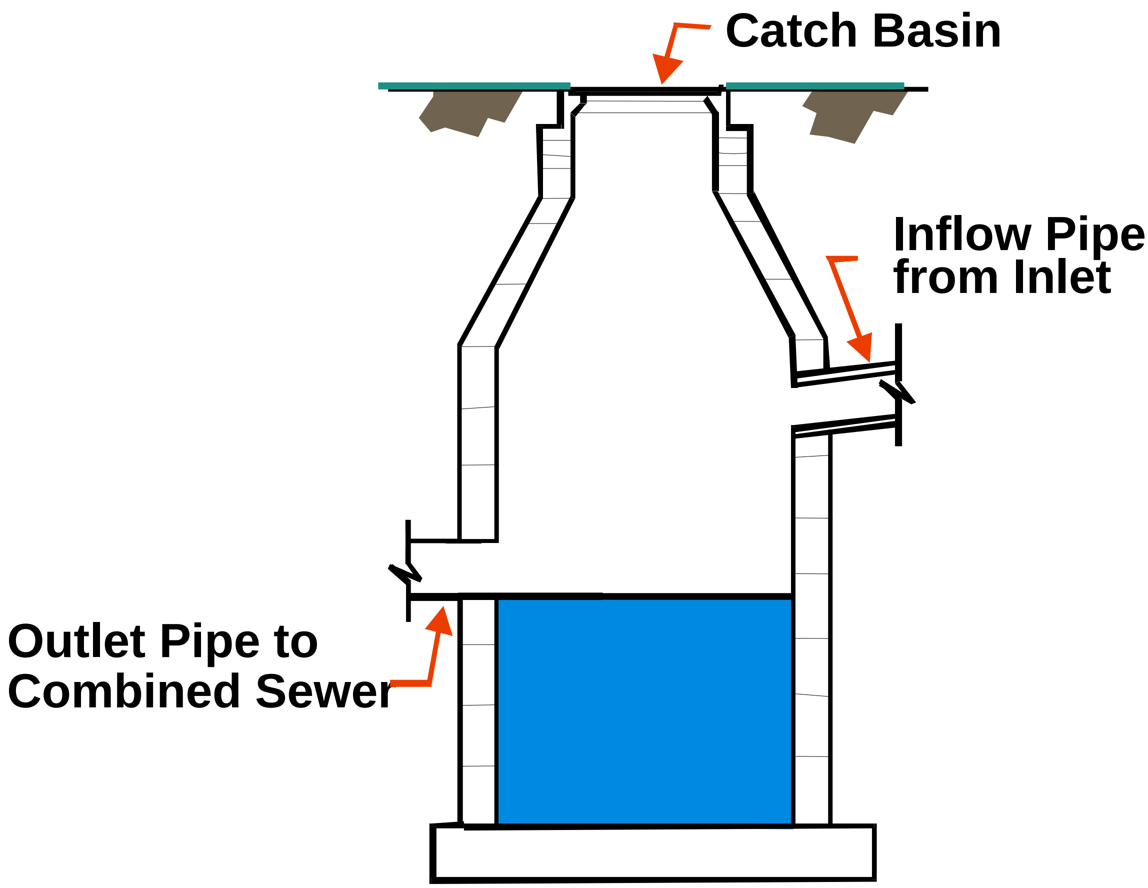

Figure 2-5. Each Skokie catch basin is a manhole-type structure with a sump.

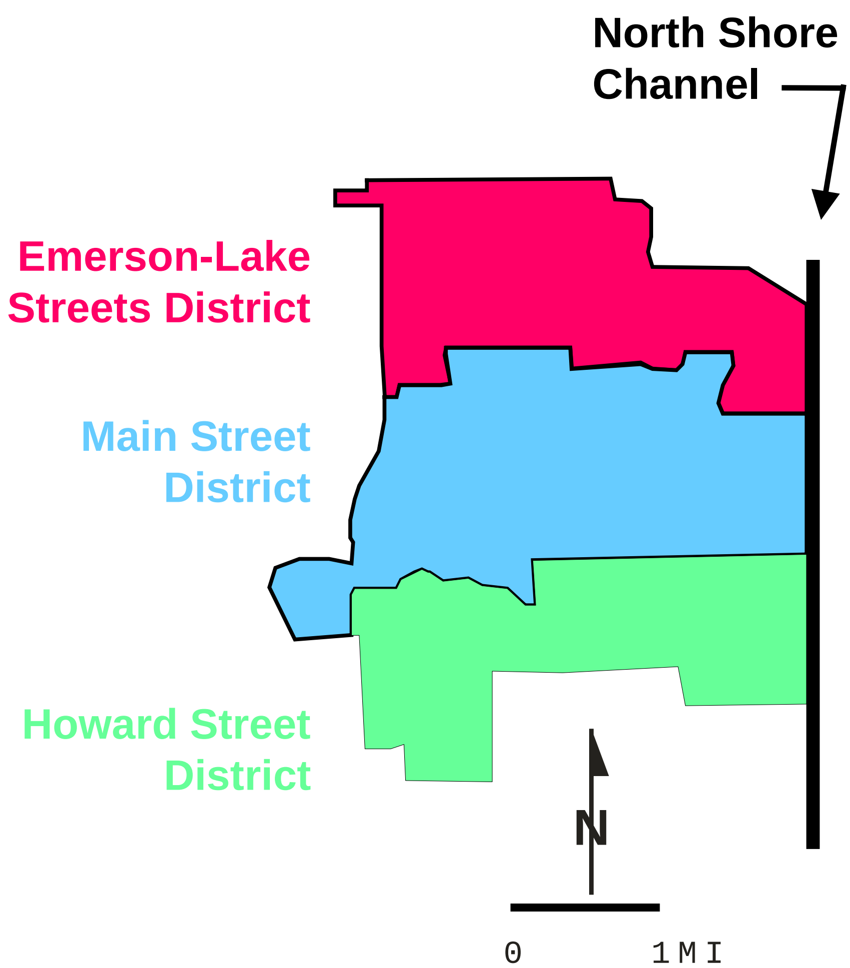

Figure 2-6. Skokie is partitioned into three easterly draining combined sewer districts.

As the area became populated in the 1800's, the need for drainage and sanitary waste disposal became critical. Construction of the North Shore Channel in 1910, as part of the overall plan to provide the Chicago metropolitan area with an adequate drainage system, provided an outlet for sewers to serve Skokie. The first trunk sewer was constructed in 1886 to drain what is now the downtown area and carried both stormwater and sewage to the channel. Skokie's combined sewer system had begun.

The prime reason for the severity of the present basement flooding problem in Skokie is tied to the 1920's—the land boom days in Skokie. Major roads from Chicago were being paved and a rapid transit line extended through Skokie. As farm land was subdivided into building lots, population rose from 760 in 1920 to 4,200 in 1930. In preparation for the anticipated building boom, the majority of streets, sidewalks, water mains and sewers were constructed. The contemporary technology resulted in the construction of a combined sewer system with its outfall at the North Shore Channel. In 1927, a treatment plant and interceptor sewer system were constructed to handle dry weather sanitary flows, but the remaining mainly combined sewage flowed into the channel.

The depression of the 1930's brought the land boom in Skokie to an immediate halt. The constructed infrastructure was left essentially unused for the next 20 years. However, development anticipated in the 1920's finally occurred in the years following World War II. The majority of development and building took place in the 1950's as Skokie's population exploded from 14,800 in 1950 to 59,400 in 1960 (Walesh and Schoeffmann, 1984).

Not only did the community commit to an entire CSS but, trunk sewers were, unfortunately, undersized. More specifically (Consoer, Townsend & Associates, 1967):

> *Because of limitations on financing, the original trunk sewer improvements were of an introductory nature and restricted in size. The lateral sewers were, however, installed to then standard practice. All of these sewers were combined storm and sanitary type.*
>
> *It had been anticipated that additions to the combined sewers would be installed at intervals as buildings were constructed in the vacant areas. However, this program was not followed and as of today, all of the trunk sewers are deficient in capacity for an acceptable level of service. Basement flooding is prevalent during medium to heavy storms, and damaging street flooding also occurs*

during the heavier storms.

In summary, this brief history highlights the community's early commitment to combined sewers and the need, driven by finances, to undersize trunk sewers. This history also provides a seque to the next major section of this chapter which describes problems caused by Skokie's undersized CSS.

Skokie's Historic Combined Sewer System Basement Flooding Problems

Several surveys over about a decade in the 1960's and 1970's documented widespread basement flooding in Skokie. According to Donohue (1982a):

> *Previous studies by Consoer, Townsend & Associates, 1967 and 1973; the Village of Skokie, 1974; and by Harza Engineering Company, 1978, have included surveys to determine the extent of basement backup flooding in the Village of Skokie. These surveys were generally conducted by sending post cards to residences requesting information on their flooding history.*
>
> *The 1967 survey received responses from over 9,000 residences with slightly in excess of 54 percent indicating that they had basement backup problems during major storms.*
>
> *The 1978 survey resulted in about 2,500 responses, a response rate of only 11 percent. Approximately 15 percent of those responding, indicated they had basement flooding from recent rains which were less intense than a 2-year frequency storm. These backup problems were spread somewhat uniformly over most of the community. Interestingly, about 20 percent of the residences having flooding problems also indicated they had at least one flood protection device that obviously didn't work properly.*
>
> *The 1974 survey by the Village was conducted only in the Fairview South area. During the survey, a questionnaire was mailed to each residence and Village personnel attempted to interview every homeowner. These efforts resulted in a 72 percent coverage of the 471*

> *units and 47 percent indicated they had basement flooding during heavy rainfall. Again, a large percent of the people with some type of flood control equipment indicated they still had basement backup flooding problems.*

Viewed collectively, the three surveys (1967, 1974 and 1978) suggest a community-wide basement flooding problem caused by surcharging of the CSS. At least half of the residences appeared to experience basement flooding in larger storms. Furthermore, basement flooding occurred in a smaller but significant fraction of residences during frequent, minor storms.

Previous Studies of Ways to Solve Skokie's Combined Sewer System Basement Flooding Problems

Skokie commissioned or conducted studies over a 15 year period to find a cost-effective solution to the growing basement flooding problem. Summarized here are the essential aspects of seven studies including the recommendations. This summary serves to illustrate how traditional solutions were repeatedly proposed but not implemented. This process, in turn, set the stage for Skokie's receptivity to a new approach.

Study Completed in 1967 Recommending Relief Sewers

Consoer, Townsend & Associates (1967) conducted this community-wide investigation. Donohue (1982a, pp. 15-16) provides this summary:

> *This study reviewed the sewer system deficiencies and backup problems in basements throughout the Village. It reviewed several alternative solutions to these sewer backup problems and recommended an overflow relief sewer system for the entire Village with an estimated 1967 cost of $22.0 million* (Note: The 1999 cost would be $123 million using the Engineering News Record [ENR] Construction Cost Index [CCI])*. In the Howard Street Sewer District the report recommended a major relief sewer along Laramie Avenue from Farwell Avenue to Brummel Street (48-inch to 102-inch diameter), then eastward along Brummel Street from Laramie Avenue to Hamlin Avenue (108-inch to 144-inch diameter), then two blocks south along Hamlin Avenue to Howard Street, and*

east along Howard Street to the North Shore Channel (144-inch diameter). These sewers were never installed.

The proposed relief sewers were designed so that the combined capacity of the existing trunk sewers and the new relief sewers would be such that runoff from about a 15-year storm could be accepted from non-restricted areas and the actual maximum possible runoff could be accepted from restricted flat areas.

Study Completed in 1973 Recommending Deep and Shallow Tunnels

With the "deep tunnel" being imminent, Skokie retained Consoer, Townsend & Associates (1973) to carry out another community-wide investigation with emphasis on solving basement flooding problems. The following summary is provided by Donohue (1982a, pp. 16-17):

*In October 1972, the Board of Trustees of the Metropolitan S*anitary *District of Greater Chicago (MSDGC) adopted the "Chicago Underflow Plan" (CUP). (This plan is later referred to as Tunnel and Reservoir Plan, TARP). The plan consisted of construction of 120 miles of conveyance tunnels intercepting the overflows from all existing combined sewers in the Chicago land area. One of the planned underflow tunnels paralleled the North Shore Channel and was scheduled for installation in the first phase of construction of the underflow plan. This provided a new outlet for the combined sewage flow from the Skokie sewer system and radically changed relief sewer concepts for the Village of Skokie. The 1973 Consoer, Townsend study analyzed the sewer facility needs for the Village of Skokie in conjunction with the CUP.*

This report recommended a system of deep and shallow tunnels connecting to the MSDGC main tunnel along the North Shore Channel. The 1973 estimated cost was $31 to $35 million (Note: The 1999 cost range would be

> $98 to $111 million using the ENR CCI). *The system within the Village of Skokie included a major deep tunnel in an east-west direction down Main Street draining towards the North Shore Channel and several shallow tunnels in north-south directions draining to this deep tunnel. The Howard Street area would be served by shallow tunnels leading north along Laramie Street and Keeler Avenue. The report presented design data and cost estimates on systems sized for both the 10-year and 100-year storms. None of these deep or shallow tunnels have been constructed.*
>
> *The study also analyzed the effect that the CUP would have on the existing trunk sewers if no relief sewers were provided. The report concludes that the North Shore Channel underflow tunnel will have a minor impact on Skokie flooding without supplementary channels or relief sewers being installed, except for several blocks near the outlet.*

Study Completed in 1974 Recommending Downspout Disconnection and Catch Basin Restrictors

Unlike all the other studies summarized in this section, this one was conducted by Skokie personnel. Donohue (1982b, pp. 17-18) contains this summary:

> *This study was completed by the Village of Skokie to determine the probable relief that could result from downspout disconnection in the Fairview South area and catch basin restrictions. The restrictors were "half-moons" inserted into catch basin outlet pipes which effectively reduce their discharge capacity by one half. Twenty-seven percent of the downspouts in the area were found to be disconnected at the beginning of the study.*
>
> *Detailed surveys were conducted by mailing questionnaires to residents of the Fairview South area and collecting these questionnaires by survey teams in the field. The survey*

covered 72 percent of the residences and showed that of those surveyed, 47 percent have basement backup problems during heavy rainfalls. The survey also asked if residences had some type of flood control equipment installed. Of the 355 residences surveyed, 86 percent indicated that they had some type of flood control equipment installed. However, a large percentage of these residences still experienced sewer backup problems due to inadequacies or malfunctioning of their flood control equipment. Another question checked the citizen response to the acceptability of a future downspout disconnection program. Sixty-nine percent of the 355 residences surveyed voiced a willingness to participate in a downspout disconnection program.

Recommendations of the study were: 1) New catch basin restrictors should be installed at 86 locations to reduce the pipe diameter from eight inches to four inches thereby reducing the discharge capacity of the catch basins by 75 percent. The cost was estimated to be $1,274. 2) A downspout disconnection program should be instituted and all residences in the study area except those fronting on Laramie and Pratt Avenues should be disconnected. Cost for this program was estimated at $19,728. The net effect of this downspout disconnection program would be a 49 percent reduction in the demand placed on the sewer system. The study stated that the additional stormwater directed into the street by the disconnected downspouts and stored in the street by the restricted catch basins could be stored without causing major hazards to vehicular traffic in all areas of Fairview South except the west and south boundary streets, Laramie Avenue and Pratt Avenue, respectively. This study used the five and 10-year storms to analyze street flooding characteristics.

As a result of this study, Skokie proceeded with a downspout disconnection program with the goal of disconnecting 95 percent of those in the HSSD in 1982. Also in keeping with the study's innovative recommendation, some restrictors were installed in catch basins. Unfortunately, most were removed because of plugging and maintenance problems (Donohue, 1982b, p. 18).

Study Completed in 1978 Recommending Deep and Shallow Tunnels and Relief Sewers

The entire Skokie CSS was the target of another study, this one conducted by Harza Engineering Company (1978). As with the 1973 study, this investigation was carried out with the understanding that TARP would eventually be a reality and, therefore, provide an improved outlet for Skokie's CSS. The following summary is provided by Donohue (1982b, pp. 18-19):

> *This study analyzed the combined sewer system in the Village of Skokie and reviewed alternative ways to improve the system performance and mitigate existing problems. The study related that the lateral sewers, characteristically about two blocks long with a maximum diameter of 18 inches, would have sufficient capacity such that backups in basements would occur only about once in 25 years if the downstream branch sewers were adequate to handle the lateral sewer discharges. These existing branch sewers, however, have about one-half of the capacity needed to convey the flow which the lateral sewers can deliver. The large trunk sewers into which the branch sewers flow have less than one-half of the capacity required to convey the flow from the branch and lateral sewers. Thus, the overall sewer system capacity decreases drastically in a downstream direction causing a flow constraint and resulting in under utilization of the upstream features of the sewer system.*
>
> *Mitigation concepts that were investigated included homeowner protection devices, reduced rate of stormwater runoff into the sewer system, separate storm sewer systems, and increased capacity of the existing sewers.*

> *The report recommended that the Village proceed with a program to increase the capacity of the existing sewers. This increased capacity would be accomplished by construction of a system of deep and shallow tunnels connecting to the MSDGC main stream tunnel system. Installation of some parallel branch sewers to convey additional flow to the tunnel system was also recommended. This system was sized to provide conveyance capacity for runoff from a 10-year frequency storm with Phase I of TARP in place and functioning. The 1978 cost estimate for these improvements was $78 million* (Note: The 1999 cost would be $168 million using the ENR CCI)*. None of the improvements have been constructed.*

Study Completed in 1981 Providing Additional Insight Into System Inadequacies

The MSDGC (now the MWRDGC) studied the performance of the ESSD after two summer of 1981 storms caused basement and street flooding (Paintal, 1981). This investigation, as summarized in the following Donohue description (1982b, pp. 19-21), characterizes the capacity problems in and other aspects of the CSS:

> *The MSDGC completed a study analyzing the performance of the Emerson Street Sewer District during two heavy storms that occurred over the Skokie area in the months of July and August 1981. These storms produced runoff rates which exceeded the capacity of the local sewer system resulting in street and basement flooding. The purpose of this study was to analyze those storms relative to the capacity of the Emerson Street sewer system. This system is a 1,740 acre area in the northern part of the Village of Skokie and is fairly similar in structure to the Howard Street system. The study analyzed the following:*
>
> - *The frequency of the July 12 and August 14, 1981 storms.*
> - *The sensitivity to flooding of the local*

sewer system relative to the water level elevation in the North Shore Channel.

- *The effects of downspout disconnection and house flood control-pumping systems on lateral sewer flows.*

Although this analysis was performed on the Emerson Street District, most of the results and conclusions are pertinent to the Howard Street Sewer District and are summarized as follows:

- *Submergence of the sewer outlet at the North Shore Channel does not affect the sewer capacity significantly if the water level in the channel does not rise above elevation 5+/- Chicago City Datum.*

- *The storms of July 12 and August 14 had a frequency of recurrence of once in 40 years and once in five years, respectively. The Emerson Street sewer, had it been designed for a five-year storm, would have adequate capacity to handle the flows generated by the above storms. The Lawler Avenue sewer (a local lateral similar to the laterals in the Howard Street District), had it been designed for a two-year storm, would have conveyed the flows generated by these storms.*

- *In order to negotiate the storms, the Emerson Street sewer should have a capacity of 1 to 1.2 cubic feet per second (cfs) per acre in comparison to the actual capacity of 0.13 to 0.2 cfs per acre. The capacity of the sewer is about one-fifth of what was required.*
- *Had the sewer been of adequate capacity, the flow at the outlet would*

have been 1,600 cfs from its service area of 1,740 acres. That is equal to 0.92 cfs per acre. It is noted that TARP (Phase I) is designed for 1.0 cfs per acre drainage intensity.

- *The results of an analysis of the Lawler Avenue (south) sewer to study the effect of downspout disconnection and individual house flood control pumping systems on the performance of the sewer system indicated that:*

    - *For short duration storms the disconnection of downspouts from the sewer system reduces the flow in the sewer significantly if the flow from the downspouts is directed to lawns and other porous areas.*

    - *The flood control pumping system protects the house but overloads the sewer system due to pumping during periods of peak flow and wet weather. If every house in the area has this kind of system, the pumpage alone will account for about 50 percent of sewer capacity depending on the size of the lateral sewer.*

Additional analyses were completed in an addendum to this report. The addendum reviewed the effect that TARP - Phase I would have in reducing sewer surcharging particularly in the lower reaches of the Emerson Street District. This analysis concluded, had TARP - Phase I been in place during the July 12, 1981 storm, sewer surcharging and basement flooding would have been eliminated or considerably reduced within about 10 percent

> *or 170 acres of the Emerson Street sewer service area which is near the sewer outfall at the North Shore Channel. A similar reduction in surcharging would be felt in the Howard Street Sewer District with TARP - Phase I completed. The actual reduction in number of basements flooded will be somewhat less in the Howard Street district since development nearest the North Shore Channel is predominately industrial and commercial with no basements.*

Study Completed in 1981 Suggesting Combinations of Traditional and Innovative Measures

Harza Engineering Company, which had completed a system wide study in 1978, was called on again to explore options (Harza, 1981). Now the principal stimulus for another study was greatly reduced probability of USEPA funding. The following summary is provided by Donohue (1982b, pp. 21-22):

> *Harza Engineering Company completed a supplemental study of flood control alternatives in 1981. This was a follow-up to their 1978 report which recommended implementation of a system of relief sewers that would connect to the Metropolitan Sanitary District of Greater Chicago's main tunnel under the North Shore Channel. Implementation of the relief sewers was predicated on a significant amount of funding coming from the USEPA. Since funding from the USEPA was no longer probable, this supplemental study was undertaken to identify solutions that could be implemented without federal aid.*

> *Alternatives discussed in the study were grouped into conveyance, flood protection, inlet control, and combinations of these concepts. The conveyance concepts included relief tunnels and sewers (estimated cost of $160 million for 10-year capacity), separate sewers (estimated cost of $120 million), and sewer lining (not adequate alone). Flood protection consisted of individual flood protection devices such as overhead sewers (estimated cost of $75 million). The review of inlet control looked at some typical depths of street flooding that would be anticipated if inlet controls were installed at the inlets without significant subsurface or other off-street storage. The cost of inlet controls alone, without storage, was estimated at $2 million. Combinations of the above were packaged to provide alternatives with the best features of each single approach to maximize benefits for targeted expenditure levels. Various combinations of inlet controls with storage and conveyance improvements were estimated to range as high as $60 million* (Note: The 1999 cost of the separate storm sewers would be $203 million using the ENR CCI. This is consistent with earlier IEPA (Park, 1990) estimates).

Study Completed in 1982 Recommending a Street Storage System

Skokie retained Donohue and Associates in January 1982 to undertake a preliminary engineering study of what was then called runoff control but, for purposes of this case study manual and as explained in Chapter 1, is referred to as a street storage system. The HSSD was selected for this preliminary engineering project as an initial study area. Included in the scope of services for this project, which was completed in July 1982, were data inventory, hydrologic-hydraulic modeling, development of alternatives with cost estimates, and implementation recommendations (Donohue, 1982a, 1982b).

As the preliminary engineering project proceeded, nine alternatives were created for the HSSD. They ranged from flow regulators only to various combinations of flow regulators, underground storage and relief sewers. All alternatives “...were intended to minimize sewer backup into basements and maximize utilization of available street flooding capacity” (Donohue, 1982b, p. 3). This was the first time that utilization of street storage was the sole basis for solving Skokie’s basement flooding problem. The series of previously discussed studies had evolved to the point where the innovative,

lower cost, street storage concept was explored in detail. The idea was to focus on the cause of CSS surcharging, that is, stormwater runoff, and explore ways to intentionally store stormwater on streets in a controlled fashion. Traditional approaches were, at least for the duration of this preliminary engineering study, held in abeyance.
The recommended street storage system consisted of approximately 1200 flow regulators, 24 supplemental storage facilities, and a relief sewer. (The constructed project required only 10 supplemental storage facilities). The storage and sewer facilities were sized, in this preliminary engineering study, for a 10-year recurrence interval storm. Flow regulators would range in location and function from modification of existing inlet grates to orifice type or energy dissipating type flow regulators installed in the sewer lines leading from catch basins or inlets to the sewer system.

Storage facilities were recommended for all areas where street ponding would exceed the depth at which damage to adjacent private property could occur. This below street or off-site storage will reduce street ponding depths to just below damaging levels.

The estimated mid-1982 construction cost for the recommended HSSD street storage system was $11,220,000. This cost was much less than the cost of traditional approaches and, as a result, was attractive to community decision makers. Opportunities to improve the cost-effectiveness of the design and reduce the total construction cost would be available as more detailed designs were prepared. Additional maintenance costs associated with the recommended street storage system were projected to be minimal.

A pilot program was recommended during the design and initial construction phase of implementation. The pilot program would evaluate various types of flow regulating devices and assess their operational aspects and maintenance requirements.

A monitoring program was recommended to evaluate the existing uncontrolled system and the performance of the pilot street storage system. The following five types of data collection and analyses were recommended: rainfall, sewer flow, street ponding, depth in storage facilities, and foundation drainage flow.

Unlike the recommendations in previous studies, the preceding recommendations were implemented. The commitment to finally take action was probably due to a combination of growing severity of the basement flooding problem and the promised low cost of the street storage system. The gradual, successful implementation of the recommendations in the preliminary engineering study, led to more recommendations which were in turn implemented. As of 1999, the street storage system has been almost completely implemented throughout the 8.6 square mile community. And, as explained in Chapter 9, the system performs very well. The details of the planning, design, testing, construction, financing and operation of the Skokie street storage system are presented in the remainder of this manual.

Observations Regarding the Studies to Solve Skokie's Combined Sewer System Basement Flooding Problem

The Skokie experience in conducting a series of studies to solve its basement flooding problem contain ideas that can be advantageously transferred to other communities. Consider the three observations discussed here.

Occurrence of a Series of Evolving Studies

In an attempt to solve its growing basement flooding problem, Skokie commissioned or conducted a series of seven evolutionary studies over a period of 15 years. This pattern of serial, evolutionary studies is common in the public works environment.

The evolutionary nature of the Skokie studies is readily illustrated. For example, the 1967 study recommended relief sewers whereas the 1973 study, informed by the MSDGC's adoption of TARP, recommended tunnels that could connect to the TARP system. Recognizing that USEPA funding was probably no longer available, the 1981 study explored more innovative, low cost options, including street storage.

The study-no action, study-no action, etc. pattern is especially characteristic of wet weather problems. This is caused by the random, episodic nature of such problems. One or more damaging episodes occur, adversely affected citizens express concern, and community officials take action by initiating a study. By the time the study is completed and recommendations made, the intensity of interest in solving the problem has diminished, especially in light of implementation costs. In contrast with the random, episodic nature of CSS, SSS, stormwater system and other wet weather problems, most public service problems persist or at least are much less episodic, until solved. Examples are deteriorating streets, poorly performing schools, deteriorating quality of water supply, and inadequate police protection.

Initial Focus on Traditional Solutions

Most of the earlier studies considered and recommended traditional solutions to Skokie's basement flooding problem. Examples are relief sewers and tunnels. Widespread consideration of—but not necessarily recommendation of—innovative options was stimulated by lack of external funding. Reductions in or limitations of financial resources encourages creativity.

Gradual Recognition of the Water Pollution Control Purpose of TARP

The series of studies and the improved understanding of TARP gradually led to the realization that while the massive, expensive TARP would mitigate CSOs it would have minimal impact on the basement flooding problem. For example, the MSDGC's 1981 study concluded that basement flooding would have been eliminated in less than 10 percent of Skokie buildings had TARP been in place during the two summer 1981 storms. Unless something was done, post-TARP Skokie would still have a massive basement flooding problem because of its CSS.

Description of Wilmette, IL

A description of Wilmette, IL is presented as a basis for understanding the case studies. Less detail is provided for Wilmette than for the previously described Skokie, for three reasons. First, some of what applies to Skokie also applies to Wilmette given that the latter is contiguous with and north of the latter. Second, more background information is needed for the much larger and longer duration Skokie project because it is emphasized in this case study manual. Third, less background documentation is available for Wilmette.

Location

As indicated on Figure 2-1, the Village of Wilmette is contiguous with and immediately north of Skokie. Figure 2-7 is a map of Wilmette showing major features. Besides being bounded on the south by Skokie and Evanston, Wilmette is bounded on the west by Glenview, on the north by Kenilworth and Northfield and on the east by Lake Michigan. The North Shore Channel, which as previously noted forms the east boundary of Skokie, passes through an eastern extremity of Wilmette before discharging into Lake Michigan. As also is the case in Skokie, the North Shore Channel, or more specifically, land paralleling it is an amenity for Wilmette. These lands include a public golf course and Gillson Park.

Relationship to the Metropolitan Water Reclammation District of Greater Chicago

Combined sewers serve the 2.0 square mile portion of Wilmette lying east of Ridge Road. Note that this CSS area is slightly less than one fourth of the CSS area in Skokie. The rest of Wilmette, which lies west of Ridge Road, is served by a separate sewer system (Loucks and Morgan, 1995). The Wilmette description presented in the remainder of this section applies primarily to the CSS area.

Wilmette's CSS lies in the service area of the MWRDGC. Combined sewers generally flow eastward. Connections to MWRDGC interceptors occur in the central portion of the CSS along Green Bay Road and on the east end of the CSS along Sheridan Road and the North Shore Channel. The Wilmette CSS is connected to TARP via two drop shafts along the North Shore Channel (SEC Donohue, December 1992, pp. 4-5). The initial CSS did not contain many trunk sewers because of the large number, relative to Skokie, of connections to MWRDGC interceptors.

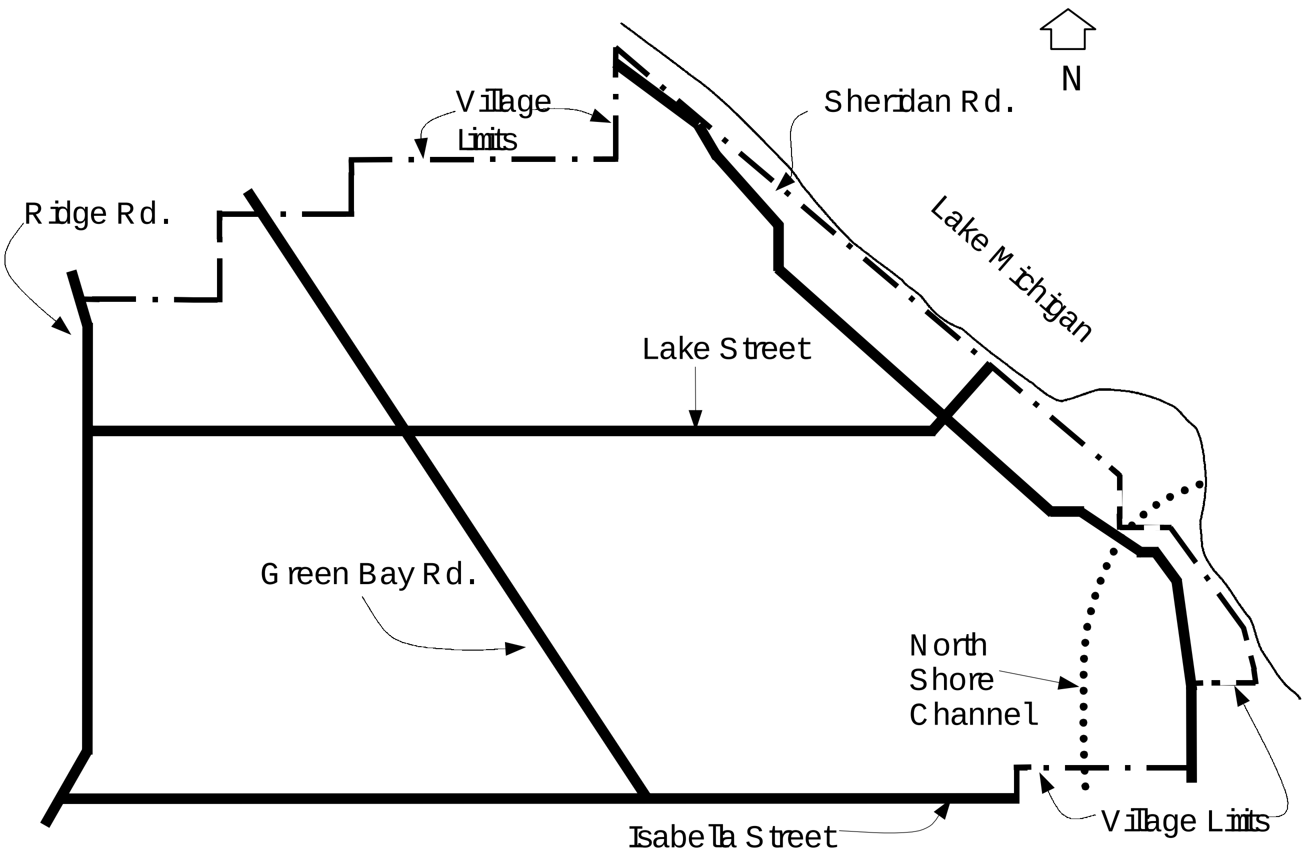

Figure 2-7. Map of a portion of Wilmette, IL served by combined sewer system.

Land Use and Population

Approximately 80 percent of the fully developed Wilmette CSS is occupied by single family residences. The remainder is commercial and multiple family dwelling units. The 2.0 square mile CSS has a population of 11,300 and contains approximately 3500 buildings. The overall population density is 9 people per acre and the population density in residential areas is about 11 people per acre. To reiterate, the area is completely developed (SEC Donohue, December 1992, p. 4).

Note that the Wilmette and Skokie CSSs are similar when compared on the basis of type and intensity of land use. Each is fully developed, about 80 percent single family residential, and has an overall density of about 10 people per acre (Skokie: 11, Wilmette: 9).

Topography and Drainage Patterns

As noted earlier, the general drainage direction within the Wilmette CSS is eastward. Longitudinal street slopes are very flat. For example, 364 street segments within the CSS having a total length of 36.2 miles were examined. A street segment would typically be one block in length. Because of traffic volume, safety considerations or steep longitudinal slopes, 24% of the streets were determined to be not suitable for street storage. However, of the remaining 76% of street segments, 66% had longitudinal slopes of less than 0.25% (0.25 feet per 100 feet), 21% had longitudinal slopes of 0.25% to 0.50%, and only 13% had longitudinal slopes in excess of 0.50% (SEC Donohue, June, 1992, pp. 12-16).

One way in which Wilmette differs from Skokie is the presence of some brick streets. Of the 26.2 lineal miles of streets available for street storage, 50% are constructed of brick, 48% of asphalt, and 2% of concrete (SEC Donohue, June, 1992, p. 15). Figure 2-8 shows one of Wilmette's brick streets. They are highly valued because of their appearance. The brick streets were fully incorporated into the street storage system without compromising their aesthetic values. For example, a mid-block berm is shown on Figure 2-8.

The CSS contains about 33 miles of sewers that vary from eight to 72 inches in diameter. Smaller sewers—less than 30 inches in diameter—are generally formed of clay tile while the sewers larger than 48 inches in diameter are made of reinforced concrete. Combined sewers in the 30 to 48 inch diameter range could be clay or concrete. No combined sewers are constructed of brick (SEC Donohue, December, 1992, p. 4).

Figure 2-8. Brick streets account for half of the street length in Wilmette targeted for street storage.

Brief History of Wilmette with Emphasis on Development of Its Drainage System

Partly as a result of the Chicago fire of 1871, the population of what is now Wilmette increased to over 300 which was the number required for incorporation. Wilmette was incorporated in 1872 and its first water and sewer systems were built in 1893-94. The combined sewer system, which was the accepted type of sewer system at that time, discharged into Lake Michigan.

As noted earlier, Wilmette, contrasted with Skokie, originally did not contain many trunk sewers because of numerous connections to MWRDGC interceptors. The entire system was generally under capacity. Relief sewers were constructed prior to 1960, but they were also undersized.

This discharge location and the shape of the Wilmette lakefront changed in the 1908 to 1910 period with construction of the North Shore Channel and the interceptor system. Spoil from the channel construction was used to create a landfill, north of the North Shore Channel, which is now Gillson Park. Therefore, Wilmette, like Skokie and many other Chicago area communities, made a major historic commitment to combined sewers and they proved to be undersized.

Wilmette's Historic Combined Sewer System Basement Flooding and Peak Discharge Problem

Like Skokie, Wilmette had a long-standing, widespread basement flooding in its CSS. SEC Donohue (December, 1992, p. 2) provides this description:

> *The combined sewer area of the Village of Wilmette... experiences basement flooding during moderate and heavy rainfalls. A postcard survey conducted following a heavy rain in August 1989 reported that nearly 800 buildings (23%) in the combined sewer area were flooded during this storm. More recent community surveys indicate that a substantially greater number of homes are actually impacted. These surveys indicate that over 60% of the buildings in the combined sewer area have been affected by basement flooding at one time or another.*

A subsequent report by Rust (November, 1993, p. 1) reports the preceding and notes that, besides property damage, flooding of basements with combined sewage exposes residents to health problems. According to this report, basement and street flooding problems "...occur regularly every one to two years during intense rain storms." The report also notes that, as a result of uncontrolled street flooding, emergency vehicles have been delayed during storms.

As Wilmette sought a solution to its basement and street flooding problem in the early 1990's, it also had to resolve a related problem. As explained by Loucks and Morgan (1995), Wilmette needed to reduce the peak discharge from its sewer system:

> *...to facilities of the MWRDGC. The MWRDGC is responsible for transportation, treatment and eventual discharge of sewage flows in Wilmette and 185 other communities. Approval from MWRDGC is required for all system modifications and new discharge connections. Projects consisting only of relief sewers are generally unacceptable. Hydraulic simulations were used to demonstrate a reduction of 28 percent in the peak discharge from the village. A maximum total peak release rate was negotiated with MWRDGC which serves as a constraint on the system design.*

Reduction in peak flow from the CSS, which was not an issue in the planning and early design of the Skokie street storage system, was a factor in the planning and design of the Wilmette system. The added value achieved in Wilmette is significant. It points to the potential for a street storage system to serve other functions such as reducing peak flows in interceptor sewers and at WWTFs.

Previous Studies of Ways to Solve Wilmette's Combined Sewer System Problems

Several studies were carried out in the early 1990's. Key studies are briefly described here as an explanation of how and why Wilmette decided to implement a street storage system in its 2.0 square mile CSS.

Study Completed in 1991 Recommending Relief Sewers

According to SEC Donohue (June, 1992, p. 5), RJN Environmental Associates, Inc. completed a facility plan for Wilmette in 1991. Focusing on solving the basement flooding problem, the plan "...recommended construction of combined relief sewers to increase the existing combined sewer system capacity to transport a 10-year storm event without surcharging." The estimated 1991 construction cost was $65,000,000. The 1999 cost would be $81 million using the ENR CCI.

Value Engineering Study Completed in 1992 Recommending Street Storage

Donohue & Associates, Inc. and Lewis & Zimmerman Associates, Inc. were retained by Wilmette to participate in a value engineering study of the previous study (SEC Donohue, June 1992, p. 5; SEC Donohue, December 1992, p. 2). Completed in January 1992, the value engineering study concluded that what is defined as street storage in this report "...appeared to offer a higher level of protection against basement flooding at a cost of $46,000,000 or substantially less than the $65,000,000 recommended in the RJN facility plan."

Study Completed in 1992 Recommending Street Storage

Wilmette retained Donohue & Associates in March of 1992 to "...determine the technical and economic feasibility of using runoff control techniques such as temporary street ponding to relieve basement flooding problems in the east side areas" (SEC Donohue, June 1992, p. 5). The scope of services for this project was similar to that of the preliminary engineering study completed by Donohue for Skokie in 1982.

Completed in June 1992, the study concluded that "...a stormwater runoff control program consisting of temporary street ponding along with relief sewers will provide a cost-effective level of protection against basement flooding in the combined sewer area east of Ridge Road" (SEC Donohue, June 1992, p. 1). The report went on to point out significant potential cost savings over the previously recommended conventional relief sewer system. More specifically, the report stated:

> *The estimated cost for a system of temporary street ponding berms and relief sewers which provide full protection against basement flooding and dedicated runoff storage capacity for a 10-year event is $28,000,000. ...The estimated cost of the 10-year ...capacity runoff control program ...is substantially less than the $65,000,000 10-year capacity combined relief sewer alternative recommended in the 1991 RJN facility plan.*

Study Completed in 1992 Recommending Refined Street Storage

Wilmette commissioned SEC Donohue (formerly Donohue & Associates) to conduct this preliminary engineering study based on the favorable findings of the previous feasibility study. One change in approach was to use a more sophisticated hydrologic-hydraulic model. The USEPA Stormwater Management Model (SWMM) was now used rather than the Illinois Urban Drainage Area Simulator (ILLUDAS). The principal purpose of SWMM was to represent the dynamics of flow in the system, that is, to rigorously simulate surcharging and backwater effects and the interaction between sewer flows and storage. Also used for the first time in Wilmette was SEC Donohue's

Surface and Street Analysis Model (SASAM). It simulated on-street conveyance and storage of stormwater (SEC Donohue, December 1992, pp. 8-9).

This refined study concluded that a system of street storage and relief sewers could control the 10-year storm for a construction cost of $31,000,000. The 1999 cost would be $37 million using the ENR CCI. Thus, this refined study essentially confirmed the preceding study (SEC Donohue, December 1992, p. 9). Details of additional planning, design, financing and construction of the Wilmette street storage system are presented in the remainder of this manual.

Observations Regarding Studies to Solve Wilmette's Combined Sewer System Problems

As with Skokie, a series of studies led to the decision to implement street storage in Wilmette's CSS. Also like Skokie, some of what was learned in the process of conducting the studies might be transferrable to other communities faced with CSS problems. Two observations based on Wilmette's experience are essentially the same as the first two of the three observations presented earlier based on Skokie's experience. They are:

- Occurrence of a series of evolving studies prior to making a commitment.

- Initial focus on traditional solutions.

Wilmette's studies differed from Skokie's in one way: they sought to solve flooding while also reducing the peak discharge from the Wilmette CSS to the MWRDGC system. This gave added impetus, as the studies proceeded, to exploring means to temporarily store stormwater for gradual release. Relief sewers alone would not suffice.